Student Projects: Hands-on Experience with Mechanical Engineering Technology

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Abstract

For several years, the Engineering Technology Department (ETD) at Middle Tennessee State University (MTSU) has sponsored a variety of student led competition vehicle programs. These programs have enjoyed considerable success in competitions around the country, and have spawned a thriving research community at MTSU, culminating with the foundation of the Experimental Vehicles Program (EVP) at MTSU during the summer of 2004.

The vehicle projects sponsored by EVP, including a Solar Vehicle, Solar Boat, Formula car, Mini Baja, and a human powered Moon Buggy, give engineering technology students invaluable experience solving real world engineering problems. The vehicle teams themselves provide a support network that introduces younger students to more experienced older students who are glad to share the hard won knowledge they have gained, and are often willing to help with homework.

This paper illustrates the effectiveness of extra-curricular student led projects in educating students for the challenges they will face on the job. EVP, along with other ETD sponsored projects, supplement the standard Mechanical Engineering Technology curriculum at MTSU by:

- Attracting new and undeclared students to the Engineering Technology Department and the Mechanical Engineering Technology (MET) concentration
- Increasing retention rates among first year MET students
- Challenging those students to apply their classroom skills in designing and building vehicles for national and international competitions
- Encouraging independent research into specific problems associated with vehicle design and construction
- Fostering effective communication, leadership, and project management skills

Introduction

The Engineering Technology Department at MTSU has recognized the importance of student projects [1] in providing a well-rounded engineering technology education. Often, engineering technology students have difficulty finding immediate applications for abstract class topics,

which leads to decreased student interest in class work and effects retention rates within the MET program.

Although the MET program at MTSU is based around great textbooks and a knowledgeable faculty, there is no substitute for hands-on learning. It has been shown that students who are involved in student projects perform better in their both their ET and general studies classes. Students involved with these projects acquire skills that are not offered in any class, like communication and leadership skills [2].

The ETD sponsored projects, and in particular the EVP vehicle teams, have proven to be an invaluable marketing tool for attracting undeclared students to the MET program [3]. The projects provide a tangible expression for the capabilities and skills of MTSU MET students, and are an exciting way to promote the program.

Because all of the EVP vehicle projects last longer than a semester, students involved with the projects tend to remain in the MET program longer. In this way, the vehicle projects help to increase retention rates [4].

Once a part of the program, MET students are quickly challenged to both apply the knowledge they have already attained through classes, and to attain additional knowledge for the completion of their project. Each vehicle project presents students with a set of unique engineering challenges. These challenges compel students to apply the knowledge they have gained in their classes, and to learn on their own.

Contact with older and more knowledgeable MET students is a great resource for younger students involved with MET projects. These older students are very eager to pass on the knowledge they have gained from past projects, and are often willing to help younger students with class work.

Attracting Prospective Students to MET

Most freshmen MET students learn of EVP and other MET student projects in their Fundamentals of Engineering class. Thanks to a few enthusiastic and supportive professors, involvement in ETD sponsored student projects has practically become part of the curriculum. For those students that do not hear of the projects, EVP has developed an innovative public awareness campaign.

One of the first tasks undertaken by EVP was the creation of brochure highlighting the vehicle projects. EVP initially used this brochure to attract attention from local businesses for sponsorship purposes, but the brochure quickly found new use as a recruitment tool[5].

EVP members hung poster-sized versions of the brochure around campus, and were startled at the response among students. At the first introductory EVP meeting, nearly fifty students, many of them freshmen, arrived to learn more about the vehicle teams. For a few undecided students, the EVP meeting was a turning point in their decision to become an MET major.

The vehicle teams experienced a similar public response when presenting their vehicles at an outdoor event on campus in mid-October 2004. The event showcased past vehicles and concepts for the 2005 competitions. Professors and students from every department stopped to talk with the vehicle teams and watch a PowerPoint presentation about the 2005 concepts. A few brave students even took a ride in the human powered moon buggy. The event generated considerable interest in the vehicle projects, as well as a few recruits for both the vehicle teams and the Engineering Technology Department.

Figure 1: Front Page of EVP Brochure

EVP has also hosted events featuring the vehicles and the vehicle teams for local middle and high schools, which have encouraged many prospective college students to pursue degrees in science and engineering. During the summer of 2005, EVP plans to host a series of workshops for high school students and teachers who are interested in forming their own Moon Buggy and Solar Vehicle teams. Through these workshops, high school students will be able to follow the actual design procedures undertaken by the EVP teams and will be prepared to begin their own projects by the beginning of the fall semester. EVP will continue to mentor these young students during the academic year.

Increasing Enrollment and Retention Rates

All of the EVP vehicle projects, as well as other ETD sponsored programs, last through multiple semesters. Students who participate in these ongoing projects tend to stay within the ETD. Because project tasks are allotted based on student interest, the projects help students to decide on a concentration and to remain within their chosen concentration.

From 1997 through 1999, the retention rate for the ET Department at MTSU dropped a total of 18%, while recruitment into the department dropped 20%, reflecting a nationwide trend in ET enrollment. In 2000, the first Solar Vehicle team was formed at MTSU. The project received considerable attention from ET students at the time, and after the competition, the vehicle was used as a recruitment tool for the department. In 2003, a Moon Buggy project was added to accommodate the growing interest in student engineering projects, followed by a Formula SAE project in 2004.

Since the formation of these projects, the enrollment rates for the ET department have improved dramatically as shown in Figure 2. Exposing prospective students to the EVP projects has had a direct impact on this rise in enrollment.

Additionally, retention rates for ET concentrations have risen 37% over the same period. Retention rates among full-time student project members have remained at 100% since the first Solar Vehicle project began.

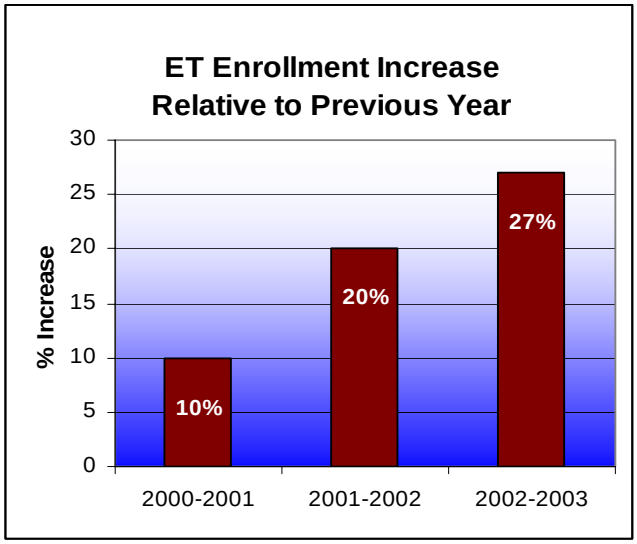

Figure 2: Relative Increase in ET Enrollment

The project teams form a support network for MET students, linking younger MET students to older, more knowledgeable students. The older students are often enthusiastic about helping their younger classmates to understand both project aspects and classroom concepts. This relationship can be very encouraging to freshmen MET students.

Challenging students to apply classroom skills

The EVP vehicle projects challenge every aspect of a student's education. For many students, the vehicle projects will mark the first time they apply statics, dynamics, strength of materials, and computer aided design techniques to a real world application.

As perhaps the most experimental of the vehicle projects, the Solar Vehicle project presents many unique engineering challenges. Competition solar vehicles are provided with a very limited supply of stored energy, so the design of the vehicle must be optimized to increase efficiency.

Members of the 2005 Solar Vehicle team investigated energy systems, and used their understanding of physics and engineering to isolate potential improvement areas where energy loss could be reduced. The team focused primarily on reducing the weight of their vehicle design over past designs, and improving the rolling resistance of the vehicle with improved wheels.

Figure 3: 2005 Solar Vehicle Chassis

The Solar Team used their mechanical engineering skills to design an extremely lightweight chassis made from Aluminum 6061 T6, an alloy common in bicycle construction. Every component of the chassis was scrutinized to ensure that the lightest possible combination of parts resulted in optimal chassis rigidity.

The team created dynamic models on paper of the vehicle in motion to ensure that the chassis would sustain the rigors of a twisting road course. In particular, the team was interested in designing a chassis that could withstand the lateral loading as the vehicle cornered, which they accomplished using the lightest weight combination of structural members.

One of the benefits of their new lightweight chassis design was the option to use lighter wheels. In their paper simulations, they discovered how a tricycle shaped vehicle experiences extreme lateral loading on the two forward wheels. Past Solar Vehicle teams had used either spoked wheels, which were prone to failure under lateral loading, or heavy solid wheels, which robbed energy from the system due to their high moment of inertia.

The team found a solution to the wheel problem in a set of fiberglass wheels, which where as light as a spoked wheel, but which could handle the lateral loading. Most importantly, the low moment of inertia of the wheels reduced the rolling resistance of the vehicle, improving overall efficiency.

Each of the vehicle teams share similar instances of applying classroom skills to their projects, which is evident in the fact that so many EVP members choose to write their senior papers on some aspect of their project.

Challenging Students to Learn on their Own

In addition to providing a means to apply classroom skills, the EVP vehicle projects also encourage students to explore additional learning opportunities. Students on each vehicle team quickly become experts in the technical aspects of their projects, whether it is internal combustion engines, power transmission, steering and suspension geometry, composite construction techniques, or electricity and electronics.

Figure 4: 2005 Formula SAE Design

One of the emerging trends among the vehicle teams is the use of computer simulation software to aid in the design process. The Formula SAE team, for example, used complex Mechanical Event Simulation (MES) software to model their suspension arrangement. The team was able to refine the geometry of their suspension and improve the handling of their vehicle before any fabrication began.

The Formula SAE team also pioneered the use of Finite Element Analysis (FEA) software in optimizing an EVP vehicle design. They used the software to create a chassis that could stand the high G forces that their formula car experiences when cornering at high speeds.

Neither of these software techniques is taught on campus, but the Formula SAE team was able to apply their knowledge of 3D CAD and the classical mechanics in order to learn how to use the software.

This trend of exploring new analysis techniques continues with the Solar Vehicle and Solar Boat teams, who are now using Computational Fluid Dynamics (CFD) software to analyze the aerodynamic and hydrodynamic qualities of their vehicles in order to optimize their designs.

The interest in Computer Aided Engineering (CAE) shown by the EVP teams has led the ET department to consider starting a CAE course, which would be a technical elective within the MET curriculum.

Extra Curricular Skills

Perhaps most importantly, students who participate on the EVP teams learn the subtleties of leadership, teamwork, research methods, effective communication, and professional demeanor, skills they might not necessarily garner in the classroom.

All of the projects are student led, which gives older students a chance to take leadership roles. These students supervise a project from start to finish, and oversee scheduling and time management, budgeting, design, and construction of their vehicles.

For younger students, learning to work as a team may be the most important thing they learn at MTSU. These students learn how to share ideas, analyze strategies, and work together towards a common goal, experience that will prove useful when they enter the job market. Because all of the EVP vehicle projects require a great deal of research, team members must develop an effective research regimen in order to investigate the many technical facets of their projects.

The team members must also learn to communicate their research results and ideas clearly, which fosters communication skills. Team members routinely write reports about their research in order to share their results with the rest of the team, and create spreadsheets and presentations to analyze the advantages and effectiveness of different design elements.

In short, students within the EVP vehicle projects develop a professional demeanor, something they might not otherwise gain with a traditional MET education. The combination of an excellent classroom education with hands-on experience makes these students very desirable in an increasingly competitive job market.

Conclusion

The student projects sponsored by the Engineering Technology Department have become an extremely useful supplement to the standard ET curriculum. By encouraging freshmen MET students to become involved with these projects, the MET professors at MTSU are giving their students an opportunity to enhance their education with a hands-on experience.

Student projects, and in particular the Experimental Vehicles Program, present students with a unique opportunity to apply the techniques they are taught in class, and to expand their knowledge of mechanical engineering in a controlled setting.

The projects also teach MET students skills they would not ordinarily learn in a traditional curriculum. Students who participate in these projects learn to work as a team, communicate effectively, lead an engineering project, and conduct themselves in a professional manner. By obtaining these skills, students within the Experimental Vehicles Program will be better equipped for future challenges.

Bibliography

1. Hirsch, P., “Enriching Freshman Design through Collaboration with Professional Designers,” 2002 Proceeding of the ASEE Annual Conference and Exposition, Montreal, Quebec, Canada, June 16-19

2. Foroudastan, S., “Mechanical Engineering Education: Not Just about the Math" 2004 Proceeding of IMECE International Mechanical Engineering Congress, Anaheim, California, November 13-19.

3. Akins, L., “Partners in Recruitment and Retention,” 2001 Proceeding of the ASEE Annual Conference and Exposition, Albuquerque, NM, June 24-27

4. Foroudastan, S., “How to Bring Reality into the Classroom through Project Innovation,” Proceedings of the ASEE Southeast Section Conference, Macon, GA, April 6-8

5. Foroudastan, S., “Capstone Design Projects: More than a Matter of Meeting a Program Requirement,” 2004 Proceeding of the ASEE Southeast Section Conference,

Biography

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Saeed Foroudastan is a Professor in the Engineering Technology and Industrial Studies Department. He received his B.S. in Civil Engineering (1980), his M.S. in Civil Engineering (1982), and his Ph.D. in Mechanical Engineering (1987) from Tennessee Technological University. Professor Foroudastan’s employment vitae includes: Assistant professor of Mechanical Engineering for Tennessee Technological University, Senior Engineer, Advanced Development Department, Textron Aerostructures, and Middle Tennessee State University. Professor Foroudastan is involved with several professional organizations and honor societies, and has many publications to his name. He also holds U.S. and European patents.

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